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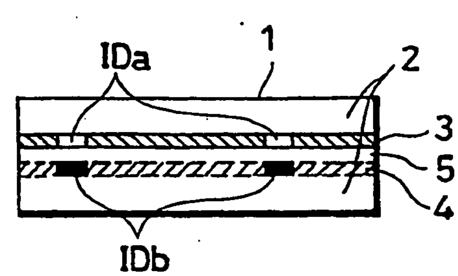
(54) **Multilayered optical disk.**

(57) A multi-layered optical disk comprising a plurality of recording layers accumulated in the thickness direction wherein a light beam is focused on one of tracks of one of the layers thereby to record and reproduce data, the optical disk being characterized in that recording layers each have an identification section storing an address of the recording layer which the identification section belongs to.

Fig. 3



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MULTI-LAYERED OPTICAL DISK

BACKGROUND OF THE INVENTION

(1) Field of the Invention

This invention relates to an optical disk used for data recording and reproduction, especially to a multi-layered optical disk having multiple recording layers.

(2) Description of the Prior Art

In recent years, this type of optical disks have been developed actively due to the large memory capacity and high access speed. An optical disk shown in Fig. 1 has been proposed in order to further increase the memory capacity.

This optical disk 12 comprises three recording layers 8a through 8c formed of a photochromic material such as spyropyrene, the layers being interposed between a pair of bases 13. The recording layers 8a through 8c have sensitivity peaks in wavelengthsλ_1 through λ_3 (Fig. 2), respectively while allowing lights having the other wavelengths to transmit therethrough.

Data recording and reproduction is done in the following way. A light is emitted from a light source 9, such as a laser, which varies wavelengths, and focused into an extra fine light beam by a focusing optical system 10, thereafter the light is illuminated on the disk 12. The light is transmitted through the recording layers 8a, 8b and 8c and is detected by a light detector 11 provided on the other side from the light source 9.

Data recording will be described in more detail. If the light emitted from the light source 9 and illuminated on the disk 12 has a wavelength λ_2, it is transmitted through the recording layers 8a and 8c but is absorbed into the recording layer 8b, whereby a data is recorded in the layer 8b.

For data reproduction, only the data recorded in the layer 8b can be retrieved by illuminating a light of λ_2.

As apparent from the above, memory capacity is increased by providing more recording layers.

However, providing more recording layers enlarges the total thickness of the recording layers. In order to record and reproduce data in such a thick disk only by use of wavelength difference without detecting exact positions of the layers, the light beam should have quite a large diameter, which prevents high density recording.

Also, the large light beam diameter causes crosstalks between neighboring tracks.

SUMMARY OF THE INVENTION

Accordingly, the present invention has an object of offering a multi-layered optical disk which detects an exact position of each recording layer for minimizing the diameter of the light beam and thus remarkably enhancing the recording density.

This invention has another object of offering a multi-layered optical disk which prevents crosstalks between neighboring tracks and layers.

The above objects are fulfilled by a multi-layered optical disk comprising a plurality of recording layers accumulated in the thickness direction wherein a light beam is focused on one of tracks of one of the layers thereby to record and reproduce data, the optical disk being characterized in that recording layers each have an identification section storing an address of the recording layer which the identification section belongs to.

The identification section may store an address of the track which the identification section belongs to.

The tracks of two of the layers neighboring in the thickness direction may be shifted against each other in the radial direction by half of a track pitch.

The optical disk may have two recording layers.

The tracks each may comprise a plurality of sectors.

The sectors each may have an identification section, which stores addresses of the recording layer, the track and the sector which the identification section belongs to.

The identification sections may be shifted against one another in the tracking direction.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, advantages and features of the invention will become apparent form the following description thereof taken in conjunction with the accompanying drawings which illustrate specific embodiments of the invention. In the drawings:

Fig. 1 is a view showing a construction of a conventional multi-layered optical disk along with a data recording and reproduction apparatus;

Fig. 2 is a view showing a wavelength spectrum recorded on the above optical disk;

Fig. 3 is a vertical cross sectional view of a multi-layered optical disk as a first embodiment of this invention;

Fig. 4 is a plan view of the optical disk of Fig. 3;
Fig. 5 is a view showing a construction of an identification section of the optical disk of Fig. 3;
Fig. 6 is a vertical cross sectional view of a multi-layered optical disk as a second embodiment of this invention;
Fig. 7 is a plan view of the optical disk of Fig. 6;
Fig. 8 is a vertical cross sectional view of a multi-layered optical disk as a third embodiment of this invention;
Fig. 9 is an enlarged view of one track of Fig. 8; and
Fig. 10 is a vertical cross sectional view of a multi-layered optical disk as a fourth embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

EMBODIMENT I

A first embodiment of this invention will be described referring to Figs. 3 through 5.

As shown in Fig. 3, a multi-layered optical disk 1 comprises upper and lower base plates 2 opposed to each other, a first recording layer 3 superposed on a lower surface of the upper base plate 2, a second recording layer 4 superposed on an upper surface of the lower base plate 2 and a spacer 5 made of UV resin for prohibiting the recording layers 3 and 4 from contacting each other. The layers 3 and 4 have known pit constructions.

As shown in Fig. 4, the recording layers 3 and 4 comprise a plurality of concentric tracks 6a and 6b, respectively (the tracks are shown in parallel for convenience in Fig. 4). The tracks 6a and 6b are shifted against each other in the radial direction by half of a track pitch Pt. Each track is divided into a plurality of sectors S, each of which has an identification section (referred to as ID_a for the track 6a and as ID_b for the track 6b) and a data field DF for storing data. As shown in Fig. 5, each identification section ID_a or ID_b comprises a section SYNC for synchronizing clocks, an address mark AM indicating a start of an address signal, a track address TA, a sector address SA and a recording layer address LA.

The multi-layered optical disk 1 is produced by forming the recording layers 3 and 4 on the base plates 2 having projecting portions and then adhering the base plates 2 with an adhesive made of UV resin (the adhesive is solidified into the spacer 5). The spacer 5 is desirably as thin as possible but a thickness of 10 to 100 µm is acceptable. The projecting portions allow the layers 3 and 4 each to have the known pit construction.

A data is recorded in the multi-layered optical disk 1 in the following way. First, a desired recording layer 3 or 4 is retrieved by reproducing the recording layer addresses LA of the disk 1. Second, a desired track 6a or 6b is retrieved by reproducing the track addresses TA of the retrieved layer. Third, a desired sector S is retrieved by reproducing the sector addresses SA of the retrieved track. Finally, a data is recorded in the data field DF of the retrieved sector S.

If a layer whose address is reproduced is not the desired one in the above first retrieval, the following operation is carried out to retrieve the desired one. The light beam is defocused and illuminated on the disk 1 while changing the position of the focus. Each time the light beam is transmitted through the layers 3 or 4, an S curve is formed to indicate a focusing error. The zero cross point of each S curve is detected until the same number of zero cross points as the ordinal number of the desired layer is detected. The ordinary number is determined as follows: when the layer 4 is the reference layer, the layer 4 is the first layer and the layer 3 is the second layer. When the above number of zero cross points are detected, namely, when the desired layer is retrieved, the light beam is focused again and the identification section ID_a or ID_b is read out for confirming that the desired layer is retrieved.

The desired track TA_1 is retrieved in the following manner. When a track address TA_2 is reproduced, the position of TA_2 is compared with the position of the desired track address TA_1, and the head of the light beam is moved by a linear motor until it reaches the desired track address TA_1 - (rough retrieval). If the desired track address TA_1 is confirmed, the operation advances to the next step of retrieving the desired sector S. If not, all the track addresses TA_2 are reproduced one by one by the tracking actuator until the head reaches the desired track address TA_1 (fine retrieval).

The desired sector S is retrieved by comparing the desired sector address SA_1 and a read address and by rotating the optical disk 1 until the head reaches the desired sector address SA_1.

Data reproduction is done in the same manner as data recording.

Since the recording layers 3 and 4 comprise identification sections ID_a and ID_b, respectively, having the recording layer addresses LA in this embodiment, whichever layer the light beam is focused and tracking on can be accurately detected. Even if the number of recording layers are increased to enlarge the total thickness of the layers, highly precise recording and reproduction is realized with high density. Providing a track ad-

dress TA in each identification section allows easy confirmation of the desired track.

Moreover, the tracks 6a and 6b are shifted against each other in the radial direction by half of the track pitch Pt. Practically speaking, therefore, the light beam is never illuminated on the adjacent recording layer, greatly preventing crosstalks between neighboring identification sections and between neighboring data fields.

EMBODIMENT II

The second embodiment of this invention will be described referring to Figs. 6 and 7. The same elements share the same numerals with Embodiment I and their explanation will be omitted.

This embodiment is distinct from Embodiment I in that the identification sections ID_a and ID_b are a little shifted against each other in the tracking direction. Desirably, the identifications ID_a and ID_b are not overlapped when seen in the radial direction.

In addition to the advantages of Embodiment I, this construction further prevents the light beam from illuminating neighboring identification sections simultaneously and thus further restricting crosstalks.

EMBODIMENT III

A third embodiment of this invention will be described referring to Figs. 8 and 9.

As shown in Fig. 8, the optical disk 1 comprises three recording layers 7a through 7c. The layers 7a through 7c have identification sections ID_{L1}, ID_{L2} and ID_{L3}, respectively. The layer 7c also has track/sector identification sections ID_{TS}, by which tracks and sectors are identified. The tracks of the layers 7a through 7c are not shifted but are aligned in the thickness direction. Each track/sector identification section ID_{TS} identifies a group of tracks and sectors which are aligned in the thickness direction. The layers 7a through 7c each have the known pit construction.

As shown in Fig. 9, the track/sector identification section ID_{TS} has a pit pitch P_1, the identification sections ID_{L1}, ID_{L2} and ID_{L3} each have a pit pitch P_2, and the data field DF has a pit pitch P_3, the pit pitches having the relationship $P_1 > P_2 = P_3$. Practically, P_1 is set so that the recorded data may be reproduced well enough if the light beam is focused on either one of the layers 7a, 7b and 7c (for example, P_1 is 5µm or less). P_2 and P_3 are set so that the recorded data is reproduced well enough when the light beam is focused on the specified layer 7a, 7b or 7c (for example, P_2 and P_3 are each 0.8 µm). In other words, the track/sector identification section ID_{TS} can be read out if only the light beam is focused on either one of the layers while the identification sections ID_{L1}, ID_{L2} and ID_{L3} can be read out if the light beam is focused on the specified layer.

How to access each layer, for example, the recording layer 7a, will be described hereinafter. In this embodiment, the layer 7c is the reference layer and the ordinal number of the layer 7a is known.

A light beam is focused on the layer 7c when a specified number of zero cross points of the S curves as focusing error signals are detected, and the identification section ID_{L3} is read out to confirm that the light beam is focused on the layer 7c. Then, when a certain number of zero cross points are detected, the light beam is focused on the layer 7a. The certain number is obtained by subtracting one from the ordinal number of the layer 7a. The identification section ID_{L1} is detected to confirm that the light beam is focused on the layer 7a. Thereafter, the track/sector identification sections ID_{TS} are detected one by one until the desired track and then the desired sector are retrieved.

In the above construction, no other signal is recorded in any portion of the layers 7a and 7b, the portion being perpendicularly opposed to the track/sector identification section ID_{TS}; and the identification sections ID_{L1}, ID_{L2} and ID_{L3} have too small pit pitches to read out unless the light beam is focused on the desired layer. Therefore, this embodiment greatly prevents crosstalks in addition to having the advantages of Embodiment I. Moreover, since the tracks of different layers are not required to shifted against one another by half the track pitch, productivity of the optical disks is increased.

EMBODIMENT IV

A fourth embodiment of this invention will be described referring to Fig. 10. The same elements share the same numerals with Embodiment III and their explanation will be omitted.

This embodiment is distinct from Embodiment III in that the identification sections ID_{L1}, ID_{L2} and ID_{L3} are a little shifted against one another in the tracking direction. Practically, the identification sections ID_{L1}, ID_{L2} and ID_{L3} are off from the track/sector identification section ID_{TS} by distances T_1, T_2 and T_3, respectively. Desirably, T_1 minus T_2 or T_2 minus T_3 is the same or larger than a length of ID_{L1}, ID_{L2} and ID_{L3} each in the tracking direction.

Since the identification sections ID_{L1}, ID_{L2} and ID_{L3} have the same pit constructions as those of Embodiment III, the track/sector identification section ID_{TS} can be read out if only the light beam is focused on either one of the layers while the identification sections ID_{L1}, ID_{L2} and ID_{L3} can be read out if the light beam is focused on the specified layer. The layer 7a can be accessed in the same manner in Embodiment III.

In this embodiment, since the identification sections ID_{L1}, ID_{L2} and ID_{L3} are shifted against one another in the tracking direction, the light beam is prevented from illuminating neighboring identification sections simultaneously. As a result, this embodiment further restricts crosstalks in addition to having the advantages of Embodiment III.

Although the tracks comprise sectors in the above four embodiments, data may be recorded all along the tracks.

In the above embodiments, the recording layers have sensitivity peaks in different wavelengths. However, the disk may comprise layers formed of an usual optomagnetic material such as TbFeCo or a phase change material such as GeSbTe.

Although the present invention has been fully described by way of embodiments with references to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.

Claims

1. A multi-layered optical disk comprising a plurality of recording layers accumulated in the thickness direction wherein a light beam is focused on one of tracks of one of the layers thereby to record and reproduce data, the optical disk being characterized in that recording layers each have an identification section storing an address of the recording layer which the identification section belongs to.
2. A multi-layered optical disk of Claim 1, wherein the identification section stores an address of the track which the identification section belongs to.
3. A multi-layered optical disk of Claim 1, wherein the tracks of two of the layers neighboring in the thickness direction are shifted against each other in the radial direction by half of a track pitch.
4. A multi-layered optical disk of Claim 3, wherein the optical disk has two recording layers.
5. A multi-layered optical disk of Claim 1, wherein the tracks each comprise a plurality of sectors.
6. A multi-layered optical disk of Claim 5, wherein the sectors each have an identification section, which stores addresses of the recording layer, the track and the sector which the identification section belongs to.
7. A multi-layered optical disk of Claim 1, the identification sections are shifted against one another in the tracking direction.

Fig. 1 Prior Art

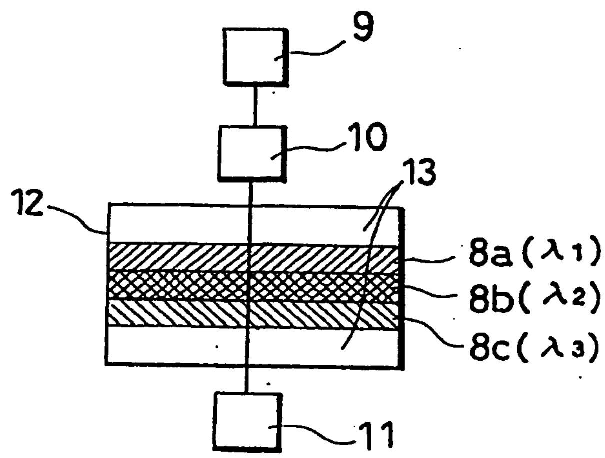


Fig. 2 Prior Art

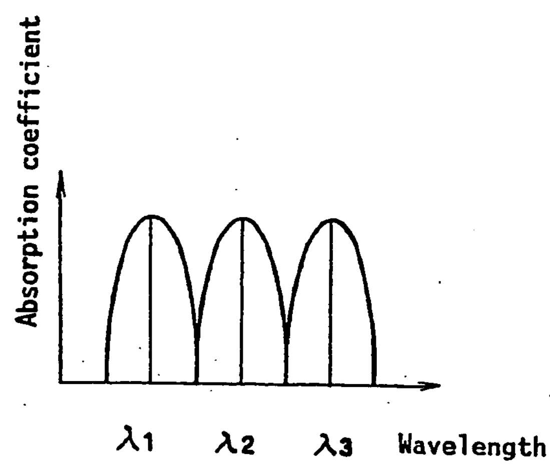


Fig. 3

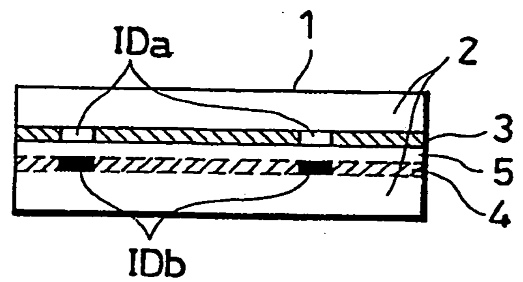


Fig. 4

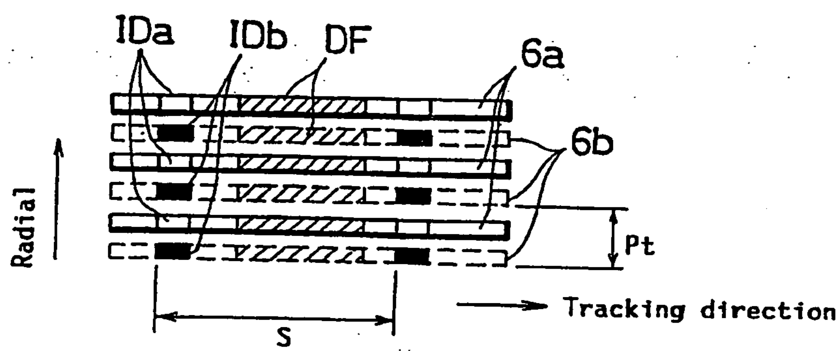


Fig. 5

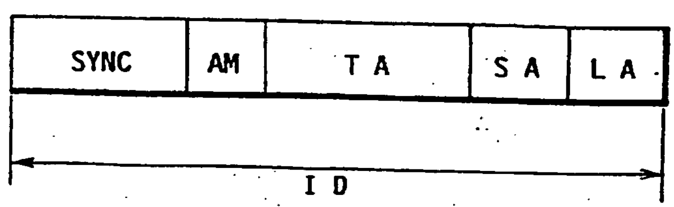


Fig. 6

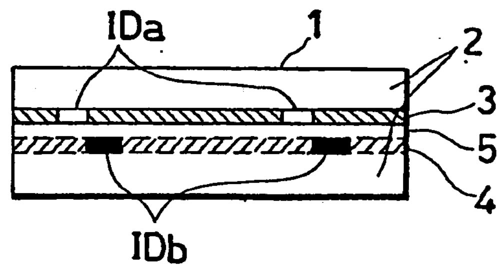


Fig. 7

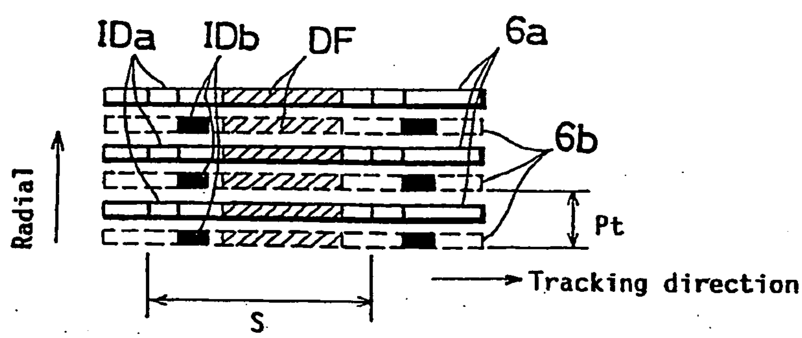


Fig. 8

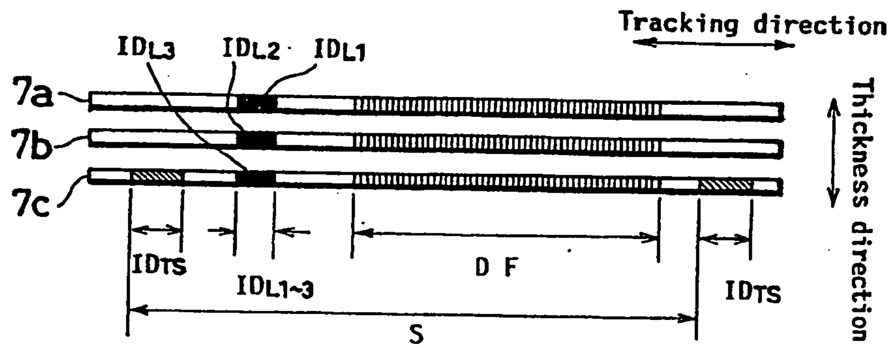

Tracking direction
IDL3
IDL2
IDL1
7a
7b
7c
Thickness direction
IDTS
IDL1~3
D F
IDTS
S

Fig. 9

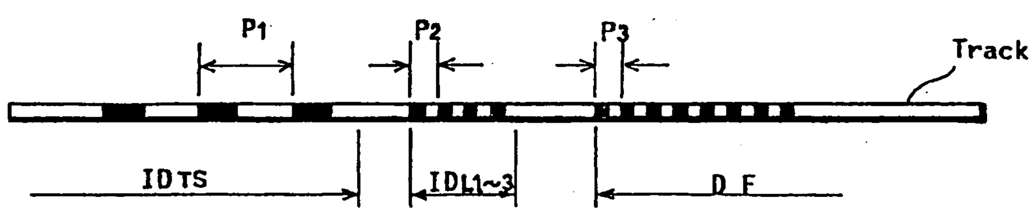
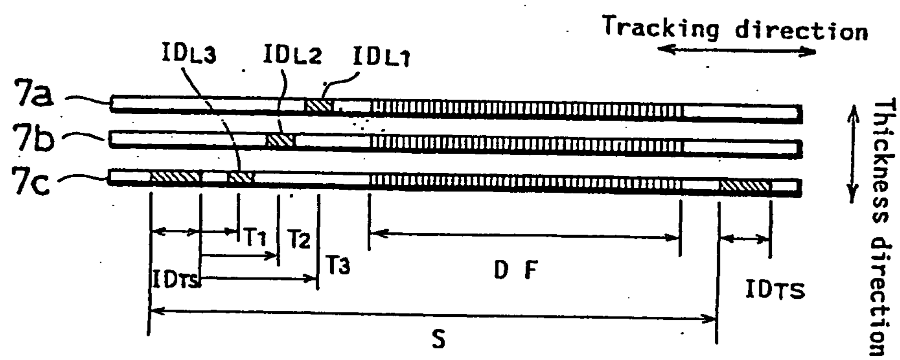

P1
P2
P3
Track
IDTS
IDL1~3
D F

Fig. 10


Tracking direction
IDL3
IDL2
IDL1
7a
7b
7c
T1
T2
T3
IDTS
D F
IDTS
S
Thickness direction